With Compliments of
George T. Stearns

UPON THE RESOURCES

— OF THE —

GREAT APPALACHIAN BASIN.

A PAPER PREPARED FOR THE COMMITTEE OF THE UNITED STATES SENATE APPOINTED UNDER THE RESOLUTIONS OF JULY 2, 1884.

BY GEORGE T. STEARNS.

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To the Honorable the Select Committee of the Senate of the United States, appointed under the Resolutions of July 2, 1884, Hon. Joseph R. Hawley, Chairman:

GENTLEMEN, — In pursuance of our understanding, I herein present some points for consideration involving the immense resources of the Great Appalachian Basin, embracing the heaviest and richest deposits of iron and coal in America, together with the heaviest growth of deciduous timber found east of the Sierra Nevadas, and their bearing upon the material and commercial interests of the country. I shall endeavor to be brief and sententious, yet I hope sufficiently comprehensive to fix the attention of the committee, and, through the instrumentality of the committee, draw consideration of the country to the wonderful and inexhaustible wealth lying dormant in this domain, awaiting the inspiration of capital and enterprise, for embedded in this territory and growing upon the surface thereof is the greater material of supply of the fundamental necessities of national greatness and prosperity. I shall fortify my statements as I progress by citing from among many a few authorites, and of whom will be names standing first among scientific authorities of this country and of Europe.

Upon the west flank of the Alleghany Mountains, embraced within the limits of West Virginia, Southwest Virginia, Eastern Kentucky, Eastern Tennessee, Western North Carolina and South Carolina, and Northern Georgia, is a territory vast in area and richer in natural deposits, probably, than any other similar territory known to exist. Well known to science, it is almost unknown to the commercial world. It is entirely undeveloped. Magnificently watered by mountain streams of purest character, with a climate of unsur-

passed salubrity, and large areas of its soil rich and fertile in high degree.

A writer in Harper's for June, 1881, (Mr. Edward Atkinson, of Boston,) says:

The mountain sides and valleys of Eastern Kentucky and Tennessee, Northern Georgia, Western North and South Carolina, and Southwestern Virginia, in many respects a *terra incognita*, is a territory larger than Great Britain, and contains more and purer iron and coal, equal deposits of copper, lead, zinc, and salt, besides corundum and gold, in its mines. It enjoys what is probably the finest climate on this continent. It is permeated by the most fertile valleys, and bears upon its hills and mountain sides the heaviest growth and greatest variety of hard wood timber. * * * The blue grass (poa pratensis) which gives the name to a considerable section of the state of Kentucky, is not confined to that state or section, but thrives in many other places; but this particular section is its special home, because the soil is underlain with rotten limestone, constantly disintegrating and furnishing the elements of fertility. * * * The rotten limestone belongs to the Cincinnati and Trenton groups of the lower silurian formation, and is very rich in fossils. The soils formed from this rock are exceptionally rich in phosphates of lime. * * * The trees consist mainly of white oak, blue ash, walnut, hard maple and hickory on the uplands, with the addition of sycamore and elm on the streams, and are as grand as any in the country. * * * This limestone region known as blue grass comprises 10,000 square miles, or 6,400,000 acres. The area of land now under cultivation in wheat in all Great Britain is less than 5000 square miles, or under 3,000,000 acres. East of the blue grass region lies the Kentucky section of the *terra incognita*. The portion of the mountain, interior valley and plateau region in the state comprises about 10,000 square miles, and is of untold wealth. * * The coal measures of this section reach a thickness of 2000 feet above the drainage level of the country, containing many beds of very superior quality. The deposits of the best quality of cannel coal are more extensive than elsewhere, and iron in beds of great richness, extent and purity, are very favorably located with reference to the coal.

Before the Windom Committee at Richmond, Va., in 1873, Gen. J. D. Imboden testified:

West of the Pottsdam sandstone outcrop of the Blue Ridge you come into the purely hematite formations of iron ore, as rich perhaps as any in the world. These are in the Blue Ridge, and west of it. The great hematite formation extends from New Jersey through Pennsylvania and Maryland into Virginia, and along with the Blue Ridge ranges on into Tennessee, Georgia and Alabama. These ores are, however, chiefly on the west side of the Blue Ridge,

and are found parallel with the mountains and cropping out almost everywhere. It is literally true that you may strike the western base and side of the Blue Ridge anywhere and find iron. * * * The coal formation in the Kanawha and the Big Sandy is the same. It is the same field precisely, and substantially the same formation. That field extends as far down as Alabama, where it is finally lost on the Black Warrior River. * * * The coal is in nearly horizontal strata; * * you find a seam on one side of the mountain; take your barometer, go over the mountain and get the same elevation on the other side, allowing for the dip, and you find the same seam, * * thus clearly running through it.

But stronger still, and, from his great eminence, necessarily the more convincing, is the testimony of the late Professor David T. Ansted of London, who for years was the President of the Royal Geological Society, viz.:

I have been occupied in practicing engineering, as connected with geology, for the last twenty-eight years. I have been accustomed to visit different coal fields and iron fields especially, in all parts of Europe, I may say, and in some parts of Asia and America. I have seen most of the important coal and iron fields in the world. * * * Here I find one of the most remarkable iron fields that exists in any part of the world as at present known. It contains every variety of the most valuable ores, and these ores are distributed in such a manner as to be more accessible than I think in any other district. * * * They include the most valuable of all the known iron ores,—magnetic oxide. They include a very large quantity of the red hematites; a very large quantity of the peculiar ore known as fossil ore, which is exceedingly valuable for iron making; a very large quantity of brown hematite and, I believe, other ores. * * * * *

With regard to coal, this is the most important of the American coal fields. * * * There can be no doubt whatever that the general coal fields west of the Alleghanies will have to supply all the manufacturing parts of America before very long. * * * The western coal field of the Alleghanies is the great coal field of America, and the Kanawha gives, I may say, the very best means of access to the coal field as it exists.

With regard to the mining of the iron ores, that can be done at a cost below the price of mining similar ores in any part of the world which I have ever visited. * * * The cost of the manufacturing of the best qualities of iron, which ought to be made from ores of such very high values, would not be much more than one-half at the present prices of labor here. * * * There are no workable coal fields in England of the ordinary kind, in which 40,000 to 50,000 tons per acre could be taken out without going to a very much greater depth than here, and the total thickness of seams in the English coal fields in any one district is not so great as it is here.

* * * The quality of the coal is quite unexceptionable. There are three kinds. The kind which is called Bituminous is remarkably free from any troublesome ash. It has a certain quality of ash, and perhaps a little more than most of the English coals, but it is capable of being coked, I am quite sure. * * * Besides this there are seams of Splint coal, — a hard coal — very valuable for household purposes, and valuable also in the manufacture of Iron, because it is so singularly free from those things which are injurious in the making of iron. It is a coal, I believe I may say, that is used * * * in furnaces in Eastern Virginia which have been erected for charcoal iron, and it has been used to replace the charcoal and the iron made from it has been found just as good as the iron made with charcoal. It is a perfectly good coal, used in the furnaces raw for the making of the best qualities of pig iron.

There is another called Cannel coal, which is exceedingly valuable, * * is the most valuable of coal for the making of gas. It has a very high gas-producing power, — a very high illuminating power. It is quite equal to our best English coals for gas, and I should think the better qualities of it are superior to our qualities of coal, say the Wigan cannel, which has always been regarded as the most useful and available of the cannel coals which have been exported. There is one coal, which is hardly a coal, either, found in Scotland, called the Bog-head, a sort of shale, containing an enormous quantity of gas, which yields, perhaps, a thousand cubic feet of gas per ton more than any other cannel known. That is the only exception. This would, I think, compete with the Wigan coal, which has been used generally in New York and in large cities on the coast. This coal could be transported to any place on the eastern coast on terms more favorable than any English coal at the present time. There is no doubt about that.

The iron bed of which I spoke runs from a hundred miles or more north of the Chesapeake and Ohio Railway, down south to Alabama, from the northern coal fields near Cumberland, through the whole of Virginia, the western side of the Alleghanies, and into Tennessee.

In the eastern part of the coal district * * * there are fourteen seams, all of them, probably, workable. * * * I cannot state the exact thickness, but when I say a workable seam I mean something more than 30 inches. * * Above the Flint Ledge,—a peculiar bench of silica that is found throughout this country, — there are four seams. Below the Flint Ledge there comes in the cannel, 10 feet below. A bed of splint and cannel, 8 feet thick and 50 feet below. * * * A crop of coal, probably bituminous, 140 feet below the Flint Ledge. Another crop at 160 feet. A mixed seam, splint, cannel, and bituminous, 7 feet thick, of coal, 220 feet below. There is also a bench which I am informed is splint, and I know it is coal, about 330 feet below the Flint Ledge. Next to that is a cannel seam * * 380 feet below. A seam below that at

500 feet. At 650 feet below a 7-foot vein of bituminous. Below that a 4-foot seam, 675 feet below. Another seam, the quality of which I do not know, 750 feet. Another seam at 760 feet; and below that is a good seam of splint and bituminous at 870 feet; and below that a seam at 1010 feet below the Flint Ledge. This section is just in the neighborhood of Hawk's Nest. * * * Below that again there are three seams of bituminous coal, all fair coal, * * that belong to the lower series. These others * * * to what geologists call the middle series. The other three that I mentioned, above the Flint Ledge, belong to the upper series. * * * These statements are strictly made upon personal observations. * * * There is a continuous layer of this coal throughout the extent, northeast and southwest, which I have mentioned, lying nearly horizantal. There is a little irregularity. * * * Judging from observation, from analysis, and from reports of actual experiment, no better coal than the splint coal in question exists in America, and certainly none can exist under circumstances more favorable for rapid and economical production.

The attention of the committee is called to the vast importance of the Kanawha River as an inland highway, and, upon the construction of a railway in a northeast and southwest course, parallel to the trend of the mountains, bisecting the territory under consideration,—the great opportunity which is available to the city of Charleston, the capital of the state, situate thereupon, as the centre and point of distribution of and for the great iron and coal producing district of the future. With all at her command that in the past has, so far as natural resources are concerned, made Pittsburgh great, Charleston has even more in its favor. To the waters of the Kanawha are tributary those of the Greenbriar, Gauley, Elk, Coal and Guyandotte, all ramifying into and cutting in all directions this vast mineral, coal and timber kingdom lying in West Virginia. It is no unfounded claim which gives to the Kanawha the capability of inaugurating a larger tonnage for distribution than any other stream in the country. When capital and enterprise join in the development of that which nature has made available, these results will follow to successful achievement. The markets of twenty thousand miles of inland water navigation await her supply. Topographically situated like Pittsburgh, at the confluence of two rivers, — the Kanawha and the Elk; surrounded upon all sides with those instrumentalities which have created Pittsburgh's wealth; below the low-water line of summer and the ice line of winter, — obstacles seriously impeding the navigation of the Ohio, with all their attend-

ant dangers, losses and delays; having a slack water navigation upon the Kanawha, created by the general government at an expenditure of several millions of dollars, whereby, practically, loaded barges can go to market every day in the year, and situated two hundred or more miles nearer to the markets of the Ohio and Mississippi valleys than Pittsburgh, Charleston has the opportunity presented to her of becoming the queen of an imperial realm. Hereabout should be erected the great iron and steel making establishments of the country and of the continent. "The proximity of iron and coal within her borders made Great Britain the foremost nation of the world." The proximity of iron and coal heretofore, for over a hundred years, has made Pennsylvania our foremost iron producing state. The conditions of her greatness no longer exist. Unpleasant as it may be to have the fact stated, practically her resources of ores are exhausted. Nine tenths of those smelted in her furnaces are brought from without the state, at heavy cost of transportation, and largely augmenting the cost of her production. Her demand upon the mines of Lake Superior amount to a million and a half tons annually, and for her a half million tons are yearly brought from the ore beds of Algiers and Spain; while the modern process, successfully working the common and phosphoretic ores into steel, is bought by the steel workers of Pennsylvania and elsewhere, and withheld from the use and advantage of the public welfare and the development of native industries, and the country is laid under contribution for a yearly tax amounting to millions of dollars that the abnormal condition of things involved in the present manufacture of steel may be sustained. This cannot long endure. As good steel can be made from the ores of the Appalachian range as from any ores in the world, and the day when the transference of the seat of this vast interest shall be accomplished is numbered; thenceforth the places which now know it will know it no more forever. The natural law controlling this industry is proximity of raw material,—the contiguity of the ore and the coal. The march southward has already commenced. In the decade ending with 1880 West Virginia increased her manufacture as against the preceding one, — as shown by the figures of the census report, — 104 per cent; and from the "tenth" assumed the position of being the "seventh" iron producing state.

Corroborative of the natural wealth of West Virginia, let me here cite from among authorities the testimony of a few. I bring you

that of the late Professor William B. Rogers, the first of American geologists, a name honored and revered throughout the world. I quote from his "Geological Report on Virginia," to wit:

That enormous area of nearly horizontal strata, which we have designated as the fifth great geological subdivision of Virginia, (now West Virginia,) * * the large territory lying between the western limits of the state and an irregular line of mountain ranges * * nearly coinciding with the eastern front ridge of the Alleghany, the Greenbriar, and the Great Flat Top mountain. * * * No section * * holds out richer promise of valuable practical results. * * By far the greater portion, if not all, of its strata belong to a group of formations distinguished not only in America, but throughout the world, as being the chief depositories of bituminous coal. * * * The western section of Virginia is characterized throughout by geographical features of great simplicity. The surface of the region is undulating, and, towards its southeastern limit, mountainous; but the loftiest hills rise in gently swelling outlines, and no very prominent peaks tower in acute and rugged lines to denote that the strata have been subjected to violent convulsions and upheaving forces. Everything bespeaks it to have been at a time an expanded plain, gently tilted from the horizontal position, so that the surface and the rocks beneath decline into a slight but very uniform depression, very generally towards the northwest, to the valley of the Ohio.

The form, direction and character of both hills and valleys, give evidence that its irregularities of surface were caused by the furrowing action of a mighty and devastating rush of waters, which by a rapid drainage scooped out enormous valleys and basins in the upper strata, the remnants of which are consequently traceable across the widest valley, from hill to hill, holding the same elevation, thickness and inclination to the horizon. It is from the deep excavation of the strata by natural causes, combined with the other important circumstances of a nearly horizontal position, that we are to draw an estimate of the prodigious resources of a mineral kind possessed by the region before us. Whatever valuable materials lie included in the strata of the district, coal, salt, limestone, or iron ore, the horizontal position alluded to keeps them near the surface, or at an accessable depth, over enormously wide spaces of country; while the trough-like structure of the valleys, and their great depth, exposes the edges of many of these deposits to the day, under positions in which mining is the easiest possible, and with an extent of development not less accommodating to the researches of the scientific geologist than bountiful to the wants of the community. * *

It is in these wide spreading strata of sandstone that nearly all the boundless treasures of this country are enclosed, and the continuous character exhibited by them give the strongest possible assurance of a like uninterrupted extension of the various beds of valuable materials which they include. In this view, how magnifi-

cent is the picture of the resources of this region, and how exhilarating the contemplations of the happy influences upon the enterprise, wealth and intellectual improvement of its inhabitants, which are rapidly to follow the successful development of its inexhaustible mineral possessions. In this country, where the channels of nearly all the principal rivers have been scooped out in part through beds of coal, where some of them are paved with the richest ores of iron, and where the very rock itself, the sterile sandstone of the cliffs and mountains, is enriched at certain depths with abundant stores of salt, what more is needed to fulfil the happy and glorious destinies that await it than to awaken enterprise to a due appreciation of the golden promises it holds out, and to direct industries and active research to the thorough investigation of the character, position and uses it contains?

Prof. Matthew F. Maury, member of American Institute of Mining Engineers, &c., reporting on the iron ores of a district of Elk River, says:

Oxide of iron constitutes, so far as has been discovered, the workable ore of this district. Its geological position is in the upper coal measures; that is, above the Black Flint ledge. * * Openings in seams of this ore have been made in Clay and Braxton counties at various places on both sides of the Elk River.

On Hamrick's 75-acre reservation, at Standing Rock Run, 246 feet (barometic observation) above the river, a deposit has been well opened, showing 5 feet and 6 feet high in the breast. The ore is a nodular brown oxide, having sometimes very rich ochre, and sometimes mud, in the interior of the lumps, which are so thickly embedded in a soft clay or shale as to make a valuable workable bed. It will yield about 35 to 40 per cent. of metallic iron, and, being soft and often cellular, will work well in the furnace. * * This vein shows by outcrop many miles up and down Elk. About 15 feet below this seam is a very encouraging outcrop, but not sufficiently tested to know its thickness.

Across the river from Friend's, on Hay's lands, a valuable bank, showing 7 feet in the breast. The Elk River Iron and Coal Company, on Strange Creek, Braxton County, at their bank on the hill behind the furnace, have very fine ore. Openings have been made at several places in this region, but the company has seen so much iron in this section that they are now content to find the blossoms, feeling assured that the seams will lie below.

Mr. Savage, president of the company, tells me he has noticed one or more of these seams at various points on either side of the river, along the whole frontage of the 96,000 acres, and feels confident that workable veins can be obtained anywhere in that distance. * * I know that at certain points good workable seams have been already proven. * * Mr. Savage further said, "I can safely say that the min-

eral resources of Elk River are very valuable, provided there was transportation. I think it will be one of the best iron districts in the United States. * * * We have found ore beds that cannot be excelled either in quantity or quality. We have ore enough within one mile of our furnace to run it for the next fifty years.

A fourth seam is found above any of these yet mentioned. It consists of a series of very red shales, in which are pockets of extremely red oxide of iron, which would work well with ores from below.

All the coal measure ores are upon the Elk River, and in greater developement there than in any other portion of the state.

Upon territory south of the Kanawha River, Prof. N. S. Shaler, formerly Chief of the Geological Survey of Kentucky, now occupying in Harvard University the chair formerly filled by Agassiz, reports:

The iron ores consist of several different beds, varying widely in their character. In the upper part of the ridges we find beds of iron oxide in the shape of the well known block ores, which have been the basis of the iron industry of the Hanging Rock district for half a century. * * * They seem to me to be as well developed as in the district about the mouth of the Big Sandy River, where they have been used for making car wheel iron for many years. They contain in a raw state about 40 per cent. of metallic iron, and the phosphorus carry is always low. * * * The above-named iron ores would of themselves afford as good a basis for an iron industry as is possessed by many of the furnaces in the Ohio Valley. * * * Considerable as they are, they seem insufficient to be compared with the main iron ore of the property, the Black Band. * * * The Black Band ore is essentially a carbonaceous shale, or impure coal, containing a large percentage of iron. * * The quality of the ore, as determined by the assays of Mr. S. P. Sharpless, one of the most competent of our living assayers, is extremely good. * * *

Prof. Sharpless says: The bed, at the point at which I examined it, * * was from four to six feet thick. * * This ore, when roasted, will yield 10,000 tons per acre. * * * The analysis of the above ore is as follows. For the purpose of comparison, I have given the analysis of two other Black Band ores.

ANALYSES.

	Davis Creek, south of Kanawha.	Hocking Valley.	Llannelly Welsh.
Silica,	3.60	4.93	7.20
Phosphorus,	.25	.87	.295
Sulphur,	.41	1.07	.26
Metallic iron,	31.46	36.43	33.68

ROASTED ORE.

Metallic iron,	64.00	50.80	56.00

Besides the Black Band ore, all the ridges on this tract are topped with one or two beds of oxide of iron, each of which is about twelve to eighteen inches in thickness. The ore runs from about 40 per cent. to 50 per cent. of metallic iron, and contains from three to four tenths of a per cent. of phosphorus.

In Coal, Iron and Oil, Prof. Daddow says of the resources of West Virginia:

The coals of this region generally are better, purer, and more available for all the requirements of trade and manufacture, than the coals of any other portion of the Alleghany coal fields. The seams of coal are more numerous, and their thickness greater; * * it can be mined cheaper and with more economy generally * * than in any other region in this country. * * * The geological reports on the coals of West Virginia make the number of workable seams to be 13, but 14 have been developed on the dividing ridge between the waters of the Great and Little Kanawha, on a line with Lewis' Creek, — and, in all probability, these are all below the Pittsburgh seam, and do not, therefore, represent all the productive coal measures of West Virginia. There are still several seams found in the higher ground back from the river. * * * A short distance above the conglomerate a small seam exists, not considered workable; but about fifty feet from the conglomerate, a variable seam is found, ranging from five to ten feet in thickness. The coal, in all probability, lies below the level of Lewis' Creek, at the forks, and is not found above water level. Above this exists the large seam of iron ore, to be noticed further on. The third seam of coal appears to be small, but varies from two to four feet. The fourth is a cannel coal of about four feet, but varies from three to six feet. The fifth seam is a hard bituminous, ranging from two to four feet in thickness. The sixth is likely bituminous, but not generally over three or four feet thick, and is sometimes smaller. The seventh seam, sometimes cannel coal, ranges from three to five feet thick. The eighth and ninth are hard bituminous seams, from thirty inches to four feet thick. The tenth seam is generally large, ranging from seven to ten feet, but is divided by fire clay, which sometimes, in practical effect, makes two workable seams of the one. The eleventh is a fine cannel seam, known as the "Peytona" cannel, five to six feet thick. The twelfth, thirteenth and fourteenth, are not opened or developed, but from appearances are known to be seams of good workable dimensions, and one of them is supposed to be cannel. * * *

This region is a *terra incognita* to the iron masters. Two prominent seams of iron ore exist; * * one on its proper geological level, as found and worked at Johnstown, Cambria County, Pennsylvania. * * * In some places it is rich and productive, while in others it is lean and worthless. Here, however, it appears at the

surface as a brown oxide of great richness, yielding 60 per cent. of metal in the furnace; but the bed is naturally a calcareous ore, when not oxidized, yielding here from 40 to 45 per cent. of metallic iron. Its size is from three to four feet when in its best condition, accompanied, however, by leaner shales or argillaceous ores. The second seam of ore is generally argillaceous, and not very rich. * * * Under such circumstances, the Great Kanawha Valley assumes an importance not hitherto noticed or discussed since the days of Washington, who first called attention to this subject and projected and predicted what the present writer now only reiterates. * * *

By far the greatest quantity of the coal used by the western steamers, and the cities on the Ohio, is mined in Pennsylvania, though the coals of West Virginia are more accessible and may be supplied with more economy.

The Great Kanawha Valley is not only a great natural mining and manufacturing region, but one that may enjoy the greatest trade that ever flowed from the mountains or the inland plains and valleys to the sea. The coal, iron, oil and salt of this region are inexhaustible, and may be produced with the minimum of labor and expense, and consequently the maximum of profits.

It is a well authenticated fact that, following the trend of the mountains as we progress southwesterly from the Kanawha River, the mineral bearing strata increases and exists in heavier deposits. Here we are in the wonderful cannel coal region. Existing in smaller degree and lighter deposits north of the Kanawha, by the denudation of that water way many miles will be passed over without a vestige being found, but special study and investigation upon the part of the writer has showed here a wealth inestimable. Commencing some distance south of the Forks of Coal, at about 20 miles from the Kanawha, veins of two, three, four feet of cannel, of very superior quality, particularly described in Prof. Ansted's testimony, are spread over wide areas of territory, and increase in thickness and richness as southerly progress is made. The Black Band deposit in this section is heavy and rich. At Workman's, on Pond Fork of Coal River, some sixty miles southerly from the Kanawha, the mountains are over twelve hundred feet, and an examination showed therein of coal, — one vein cannel, 3 feet; same vein of splint, 3 feet; one vein cannel, 3½ feet; one vein cannel, 4 feet; one vein bituminous 10 feet; one vein cannel and bituminous, 9 feet; four veins bituminous, 4 feet each; three veins bituminous 5 feet each; 10 veins bituminous, from 1½ to 2½ feet each; also Black Band and Red Hematite ores, veins unopened and unmeasured.

And so on through a region constantly increasing in the richness and quantity of its deposits, we cross the head waters of the Coal, the Guyandotte, and the Big Sandy, till we reach the boundary line of the state, and pass over into Kentucky.

The stronger influences for good within her borders are indefatigably working in this great state to redeem her past errors, and put her into position to enjoy the benefits of that which her geographical position, her varied and inexhaustible resources, her genial climate, her wealth-producing soil, make her capable. The vast and varied instrumentalities of her wealth, long dormant, are by the vigorous and intelligent efforts of her Geological Survey being brought to the knowledge of the world, and it would seem that ere long capital will make haste to secure the golden reward which the opening up of her resources and the development of her industries surely promise. For the purposes of this paper, a general discussion thereof would probably be deemed beyond the purview of the resolution of the Senate under which the Committee act. In all that I have said I have felt the restraining limitations of that authority. It will however, I trust, be deemed proper for me to suggest certain points of interest appertaining to the Eastern carboniferous section, comprising the eastern portion of the state, and aggregating some 10,000 square miles,—nine tenths thereof being covered with primeval forest. It is hardly essential to discuss this great subject in the aspect of its relation to the material interests of the country at large, or its peculiar value for making charcoal iron. Rapidly as our forests are being destroyed, those who have studied the timber question cannot fail to see at once the inestimable value herein involved, or how necessitous soon will be these vast forests to meet the absolute needs of the country's requirements. Especial attention, however, is asked to the wealth of the section drained by the Big Sandy, the Licking, the Kentucky, and the Cumberland rivers, all finding their source of supply in the mountains in the southeastern portion of this state, in iron and the cannel and coke-making coals. Stating the general fact that herein lies the greatest deposit of cannel coal known, and fully as rich, if not richer than the coals of southern West Virginia, it is essential only to add that the veins here run five, six, even seven and more feet in thickness, and that the coal measures aggregate in excess of two thousand feet,—thicker than elsewhere in America.

Iron ores not as rich as are found in this vicinage, it is claimed,

are, in the more northern states, carried hundreds of miles to be smelted. These consist, most generally, of the "Clinton," "Dyestone," and "Fossil." Along the Alleghanies, from Canada to Alabama, this Clinton ore is to be found, — is of good workable thickness, and is the principal supply, from local workings, of the Pennsylvania furnaces. In Mr. P. N. Moore's report on "The Iron Ores in the vicinity of Cumberland Gap," it is shown that the beds in the section near the Gap run from twenty-two to twenty-seven inches in thickness; eighteen miles east from the Gap, fifty-two inches; and at or near Big Stone Gap the several beds range from twenty-five inches to seven feet and a little over. In quality it is superior to the Clinton ores of other localities, as shown by the following analyses, made by Dr. Robert Peter, Chemist of the Kentucky Geological Survey.

ANALYSES.

Specific gravity,	3.942	3.914
Iron Peroxide,	77.380	73.935
Alumina, Manganese Oxide,	3.941	5.776
Lime Carbonate,	.420	4.510
Magnesia,	Tr.	.266
Combined water,	2.500	3.850
Silica and Silicates,	15.960	11.730
Percentage of Iron,	54.166	51.750
" Phosphorus,	.140	.140
" Sulphur,	Tr.	Tr.

The following are analyses of ores from the Big Stone Gap district, by Mr. McCreath, Chemist of the Pennsylvania Geological Survey. Assays of Clinton ores of Pennsylvania, for purposes of comparison, can be found in volume F, Second Survey of Pennsylvania. No. 1, Clinton ore; No. 2, Brown Hematite.

ANALYSES.

	No. 1.	No. 2.
Metallic Iron,	52.600	52.556
Sulphur,	.018	.037
Phosphorus,	.116	.051
Insoluble residue,	18.140	7.840

The following are analyses of ores from a westerly portion of the basin, made by Dr. Robert Peter for the First Geological Survey. (See Second Chemical Report, p. 276, vol. II, Old Series, Kentucky Geological Reports.)

ANALYSES.

	A.	B.	C.	D.	E.
Carbonate of Iron,	73.35	73.13		67.72	63.60
Oxide of Iron,	3.36	4.94	80.50	6.99	
Carbonate of Lime,	.88	1.15	.18	3.38	
" Magnesia,	2.67	1.59		10.15	
" Manganese,	1.49	3.74		.70	
Alumina,	.58	.79	1.88	1.58	2.98
Phosphoric Acid,	.63	.16		.76	.31
Bituminous matter,		3.25			
Silex and insoluble silicates,	9.88	9.95	2.48	8.48	17.25
Moisture and loss,	1.16	.63	12.66	.56	13.75
Percentage of Iron,	39.20	38.81	56.37	37.60	44.53

A, Carbonate of Iron, Log Mountain,
B, Ditto, under Cumberland Falls,
C, Limonite, head waters of Mud Creek,
D, Carbonate of Iron, mouth of Poplar Creek,
E, Limonite, south part of Pine Mountain,
} Whiteley Co., Ky.

It is claimed that in no region in the United States can iron be produced cheaper than in the area between the Pine and the Cumberland mountains.

And now of vast importance to the iron-making interests are the developments and demonstrations of the Geological Survey in the matter of the remarkable coking coals of the territory of the upper waters of the Big Sandy, Licking, Kentucky and Cumberland. I quote Prof. Proctor, Director of the Geological Survey, thereupon: (See Report of the Survey from January, 1882, to January, 1884.)

In the Summer of 1881 the survey discovered a very thick coal of great purity, and tests in the laboratory indicated that it was a coking coal of superior excellence. During the Summers and Autums of 1882 and 1883, the party in charge of Prof. Crandall was engaged in tracing this coal, determining its area and thickness, and making practical tests of its coking properties. * * * The following facts have been established. This coal, which has been named for convenience of reference the "Elkhorn Coking Coal," has been identified and traced over a large area on the head waters of the streams above mentioned, where it is found to be from eight feet to nine feet thick, with conditions favorable for cheap mining. On the outer rim of the basin of thickest coal the same coal is found extending over a considerable area with a thickness of from four feet to eight feet. * * * The following analyses from carefully arranged samples are by Dr. Robert Peter and his assistant, A. M. Peter, chemists of the Geological Survey.

ANALYSES.

No. in Chemical Report,	2,403	2,404	2,266	2,352	2,356	2,361
Specific gravity,	1.271		1.254	1.291	1.286	1.319
Hygroscopic moisture,	1.60	1.80	1.10	3.26	1.46	2 86
Volatile combustible matter,	29.36	26.80	36.44	32.24	33.26	31.54
Coke,	69.04	71.40	62.46	64.50	64.90	65.60
Fixed carbon in coke,	67.40	67.60	59.66	61.60	59.70	62.10
Ash,	1.64	3.80	2.80	2.90	5.20	3.50
Sulphur,	.610	.967	.613	.656	.678	.535

Nos. 2403 and 2404 are from the coal in the basin of the head waters of the Big Sandy River; No. 2266 from the Upper Cumberland; and Nos. 2352, 2356 and 2361, from the Upper Kentucky River.

For purposes of comparison, I give below analyses of the celebrated coking coals of Pennsylvania.

	1.	2.	3.
Water, at 225°,	1.260	.950	N.E.
Volatile matter,	30.107	29.662	31.36
Fixed carbon,	59.616	55.901	59.62
Sulphur,	.784	1.931	7.84
Ash,	8.233	11.556	8.23
Coke,	68.633	69.388	68.00

Nos. 1 and 2, Connellsville Coking Coal, analyses by McCreath, from Second Geological Survey of Pennsylvania, vol. M M, p. 22; No. 3, Connellsville Coking Coal, Pittsburg seam, Second Geological Survey of Pennsylvania. Special Report L, p. 120.

The following table of analyses of cokes * * will show the excellent character of the coke made from the Kentucky coals. Analyses of Pennsylvania cokes are given for purposes of comparison.

	Kentucky Coke.				*Pennsylvania Coke.*		
	1.	2.	3.	4.	5.	6.	7.
Moisture expelled at red heat,	.20	1.20	1.10	.60	.460	6.10	.50
Fixed carbon,	93.20	94.14	95.40	93.34	89.576	84.721	88.773
Ash,	6.60	4.66	3.50	6.00	9.113	12.636	9.512
Sulphur,	.734	1.484	.517	1.335	.821	1.994	1.328

No. 1, from Elkhorn Coal, made in an oven at Cincinnati; No. 2, from Elkhorn Coal, made in an oven in Connellsville, Penn.; No. 3, made from Elkhorn Coal; No. 4, made from Bell County Coal; Nos. 5, 6 and 7, Connellsville, Penn., Coke; No. 6, used at iron works of New Castle, Penn.; and No. 7, used by Cambria Iron Company, Johnstown, Penn.

The value of coke for the manufacture of iron is demonstrated by the rapid increase in the production of coke iron in the United States. The following figures show the increase since 1873:

	Anthracite.	Charcoal.	Coke.
1873,	1,312,754	577,620	977,904
1880,	1,807,650	537,558	1,950,205

The value of the Elkhorn Coking Coal is determined by the following conditions: 1, Superior quality, and cheapness by which it may be mined; 2, Ease by which it may be brought to the Ohio

Valley and the furnaces of Eastern Kentucky and Western Ohio, by proposed railways; 3, The nearness to cheap iron ores of superior quality; 4, The position with relation to the South Atlantic States, there being no coal between the southeastern border of this coal-field and the Atlantic ocean.

Prof. W. C. Kerr, State Geologist of North Carolina, is authority for the astounding statement that the Cranberry ore beds of that state are "in quality unsurpassed by any iron in the world, and, in regard to quantity, the bed much exceeds the great deposits of Missouri and Michigan, and at least equals anything in the Champlain region, so that it has not, probably, an equal in this country." (See Geology of North Carolina, Vol 1, 1875, p. 266.) Specimens of this ore analyzed as follows:

ANALYSES.

	No. 1	No. 2	No. 3	No. 4	No. 5
Magnetic Oxide of Iron,	94.37	91.45	85.59	80.77	91.89
Oxide of Manganese,	0.29	0.06	0.24	1.42	0.32
Alumina,	0.42	0.77	0.11	0.52	1.03
Lime,	0.43	1.01	0.72		1.06
Magnesia,	0.36	0.53	0.33		0.23
Water,		0.44	1.53	8.21	1.15
Silica, Pyroxene, &c.,	4.16	5.74	11.48	9.08	4.02
Metallic Iron,	68.34	66.22	61.98	58.49	66.58

The assays of four of these samples was by Dr. Genth, who reported thereupon: "The first three samples contain neither titanic acid nor phosphorus. The fourth contains a trace of phosphoric acid. No. 5 was analyzed by Prof. Chandler, School of Mines, Columbia College, New York, who said thereupon: "This is the best iron ore I have ever analyzed. It is a very rich in iron and very free from sulphur and phosphorus."

An extension of this bed, similar in the character of its ores, is developed in Carter County, East Tennessee. Other valuable ores are found in Carter and Johnson Counties; analyses of three specimens are given:

ANALYSES.

	No. 1.	No. 2.	No. 3.
Combined oxygen,	25.60	22.07	24.29
Water,	.22	5.41	.67
Silica,	2.17	10.32	6.30
Sulphur,	.06	.03	.06
Phosphorus,	.003	.09	.07
Metallic iron,	59.75	51.50	63.72

High grade ores are found in other counties of East Tennessee,—Greene, Cocke, Blount, and elsewhere, and upon the deposits of ore in Bompass Creek, Washington County, a paper was read by Prof. J. P. Lesley, before the American Philosophical Society, May 3, 1872.

Troost, in his Fourth Geological Report on Tennessee, makes special reference to an extensive vein of magnetic iron ore, similar to that of some parts of Sweden, situated at the foot of Roan Mountain.

Elsewhere, summing up the result of investigations on what he characterizes "The Tuscarora Iron Ore Belt in North Carolina," Prof. Lesley says:

It is an advantage, therefore, that while many Canada ores hold 25 and 30 an 35 per cent. of titanic acid, your company's ore has less than 15, leaving the percentage of metallic iron over 50. At the same time you have all the advantages which the presence of titanium affords: 1st, Making the *ore* so firm that it is the best possible for lining puddling furnaces; 2d, Making the *iron* tougher and harder, like the best Sweden iron; and 3d, Imparting a certain quality (the cause of which is not yet understood) which adapts the *iron* especially for the manufacture of *steel*. The quality of the ore * * is of the very first rate; none better in the world. The soft ores will smelt easily and make magnificent iron; absolutely the very best,—perfectly malleable, tough and strong. The hard ores will command a high price for puddlers' linings; will be in demand for mixing with poorer ores of other regions in the blast furnace, to increase the quantity and quality of their pig metal, and will have an especial value for the Siemens and Bessemer processes, and the steel manufacturers generally. The quantity of the ore is limitless.

Prof. Proctor further says (Report, 1884):

On top of the sub-carboniferous limestone brought up by the great Pine Mountain fault, there is an excellent iron ore near the Elkhorn coking coal. Along the border of the state, in Southwest Virginia, is an extensive deposit of the Clinton or "Fossil" iron ore, — a very cheap ore, — only a few miles distant from this Kentucky coking coal, whilst there is an abundance of high grade ores in the valley of Southwest Virginia, and in western North Carolina is an extensive deposit of what is probably the best steel making ore in America.

Prof. Shaler, who for over six years was at the head of the Geological Survey of Kentucky; who was Geologist in the Coast Survey in the Virginia district, and for several summers in Central and Western Virginia has been in charge of the work of the Harvard Summer School of Geology, — and who from his eminent scientific position and practical experience is an authority of high character, says of this territory:

I affirm my conviction that the belt of country lying between the parallels of 36 and 40 degrees, and from the Atlantic west to the

Mississippi, contains the greatest and most varied mass of mineral resources of any equal area on this continent, — resources destined to play a very great part in the future industries of this country. * * * Its economic future lies in the fact that it is the richest field of mineral wealth known in any country. Placed between the agricultural districts of the Atlantic slope and the Mississippi valley, these vast stores of coal, iron, copper, zinc, and other mine products, are admirably situated for the use of the populous states that are now growing up in those sections. * * *

The Alleghany range of mountains contains in its folds and on its flank great areas of petroleum, and several levels where waters thickly charged with salt are found. There are also abundant deposits of fire and pottery clays in the coal series. Taken in its entirety, this coal-bearing belt is * * the richest field in either America or Europe.

In Mr. Swank's special report to the Census Bureau, 1880, p. 168, upon the steel and iron industries, he says:

From the ore mines of Lake Superior and Missouri to the coal of Pennsylvania is one thousand miles. Connellsville coke is taken six hundred miles to the blast furnaces of Chicago, and seven hundred and fifty miles to the blast furnaces of St. Louis. The average distance over which all the domestic iron ore which is consumed in the blast furnaces of the United States is transported, is not less than four hundred miles; and the average distance over which the fuel which is used to smelt it is transported, is not less than two hundred miles.

In the Appalachian Basin the average haul of the ore to the fuel, and the fuel to the ore, would not be more than one hundred miles, if so much.

It will be seen that the great essential necessity to make this vast wealth available is railway transportation, a longitudinal line of road, bisecting this basin, thereby connecting the great railway systems of the North with the great roads of the South, with branch roads radiating therefrom to the more important working fields. It is the most important work that affects the welfare of the nation, and therefrom will be quickened into being energies now latent and dormant, which will give force and character to the progress of mankind.

Gentlemen: I have gone far beyond my intention when I undertook the preparation of this paper, but the scope and magnitude of the interest involved will, I hope, be ample apology for the claim

thereby made upon your consideration. Many as are my authorities summoned, I have, as it were, but commenced upon the available force. Enough is given to furnish food for intelligent thought and the action of a wise statesmanship. To your contemplation, and that of the great constituency behind you, I commend, as the vast source of supply to the country of the fundamental elements of national prosperity, the GREAT APPALACHIAN BASIN.

GEORGE T. STEARNS.

NEW YORK, Aug. 11, 1884.